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ABSTRACT

Word recognition and reading failure are examined in this report using an interactive framework of the reading process based on the premise that reading is both a top-down and a bottom-up process, both conceptually guided and graphically based. Experiments are discussed that show that less-skilled readers are affected by anomalous contexts and that they do make accurate predictions. Experiments in which print is degraded (letter segments are deleted) are also described, indicating that both the accuracy and the identification times of less-skilled readers were helped more by context. The conclusion notes that middle grade children of normal intelligence who are poor readers can use context very well in word identification and that they show signs of being dependent on context in compensation for inefficient word coding abilities. (MKM)

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Consider the process of reading the following brief text excerpt.

(1) Alice was ready to board the train. She reached in her purse to get her _____.

Readers of (1) will typically have a fairly high expectancy to encounter the word ticket at the end of the second sentence. They will similarly have some expectancy concerning the final word of the first sentence. It is likely to be the word plane, airplane, train, bus, etc. Thus the word that actually occurs (train) is probably not the most probable word in the text at that point. It is rather one of a set of likely words that can occur.

The text example (1) illustrates a fairly obvious point about reading. The identification of words is potentially made easier by comprehension of the previous text, or more generally, by knowledge that is relevant for the content of the text. Since the relevant knowledge can come from the reader's mind, as well as from the text, it is a very general conceptual knowledge that guides reading. In an important sense then, reading is conceptually guided or "top-down." This conceptual guidance aspect of reading has been strongly

emphasized by Goodman (1976) and Smith (1971) and in some theoretical detail by Rumelhart (1977).

Of course, there's more to reading than conceptual guidance. There is also the process of identifying words by matching graphic inputs to stored representation of letters and words, i.e., decoding. It is a happy state of affairs that such a process depends not wholly on conceptual data but, in a fundamental sense, on graphic data. Any normal reading situation will involve mutually supportive interplay between graphic data and conceptual data, or between "bottom-up" and "top-down" processing. However there is an important asymmetry between conceptually-guided and graphically-based processes. The latter can carry on without the former but not vice-versa. No matter how helpful conceptual data are, they are neither essential nor definitive.

Top-Down and Bottom-Up Sources of Reading Failure

It is possible to bring this framework to bear on problems of reading failure. Within an interactive framework, i.e., one which describes reading as an interaction between top-down and bottom-up processes, one can ask about types of reading failure by referring to a reader's higher level conceptual abilities and his/her lower level verbal abilities.

There are two general possibilities that simplify to a great extent the full range of possibilities. One possibility is a reading problem which is based on ineffective bottom-up processes, or, equivalently, ineffective use of graphic data. It is not only the

child who can't read words who fits this description. It is also the child who reads words with acceptable accuracy but does so with effort or without speed (which are not quite the same thing). This child's verbal inefficiency is detectable when the latency of word identification is measured. For example, a 10-year old reader of low skill may take about 120 milliseconds more than a skilled reader to begin to say a common one-syllable word (Hogaboam & Perfetti, 1978). If the word to be identified is longer or less common or, especially, if it is a pronounceable nonword, the extra identification time of the less-skilled reader greatly increases (Hogaboam & Perfetti, 1978; Perfetti & Hogaboam, 1975). By this account, the typical child of low reading skill lacks the efficient (fast) verbal coding process of the skilled reader.

This coding problem changes to a comprehension problem when the child confronts text. In text, inefficient verbal coding is competing with other comprehension processes. One result can be the partial loss from active memory of recently constructed meanings. This is, of course, a loss of comprehension. A secondary result might be a reduced level of effort by the reader.

A contrasting possibility is that a reader has an impaired ability to make use of conceptual data. This child might have adequate, i.e., efficient, coding processes but would fail to use context and conceptual knowledge to guide word identification. His failure is top down, not bottom up. Another way to describe this sort of failure is the reader has failed, for some reason, to transfer his or her language understanding ability to comprehension of printed

language.

The question to be addressed is the relative pervasiveness of these two sorts of reading failure. The evidence is very strong that children who have trouble with text comprehension tend to be slow at word coding. Thus the question reduces to whether young less-skilled readers also fail to use context.

Some Research on Identification in Context

One way to get at the relative contribution of conceptually guided and data driven processes to reading is to manipulate the quality of the conceptual data and the quality of the graphic data. For example, consider again the brief text (1) that began this article. The completion of text (1) by the word ticket is expected on the basis of conceptual data. By contrast, reading the word ticket as an isolated word or as part of an arbitrary list eliminates conceptual data. Thus, in context the demands on bottom-up processes are reduced. Out of context these processes are solely responsible for correct identification.

The research questions are how context affects word identification and whether the effects are similar for skilled readers and readers of less skill. The general effect of context on word identification is well established (e.g., Tulving & Gold, 1963) although the mechanism by which the effect is made is still an active research question. By one account such effects are additions to other sources of information available to a memory which stores words and accepts information from all sources in raising the activation level

of a word (Morton, 1969). Other accounts distinguish between unconscious activation of words by context and conscious expectation of words produced by context (Posner & Snyder, 1975; Stanovich, in press; Stanovich & West, 1979). In most general terms, the effect of context is a matter of identification priorities accruing to some words over others. It seems unlikely that conscious anticipation mechanisms would be responsible for this process in general, especially for highly skilled readers, whose rates of word identification would be too fast to allow for slower anticipation processes.

Perhaps the context effect most important for ordinary reading is the one resulting from identification of words in normal texts. Perfetti, Goldman and Hogaboam (1979) presented complete stories that had occasional single words to be identified as quickly as possible. The subjects were fifth grade children of normal and above IQ from a normal classroom. They were classified as skilled and less-skilled readers on the basis of a comprehension test. In one experiment, the stories were presented aurally except for the isolated words to be identified. Our reasoning was that we wanted to be sure that any inability to use context could not be attributed to inability to read the context. Children heard the story on an audio tape which also signalled the imminent appearances of a word on a screen. Their latency to correct word identification could be compared with conditions of isolated presentation.

The results were that context reduced the identification latencies of both skilled and less-skilled readers, but it reduced the

latencies of less-skilled readers more. Story context reduced the latencies of less-skilled readers by about 300 milliseconds over a wide range of long and short words of high and low frequency. The effect for skilled readers were about 120 milliseconds. With context, identification latency differences between skilled and less-skilled readers were reduced to an average of 86 milliseconds from an average of 283 milliseconds out of context. The results are clear. Less-skilled readers can use context to facilitate the identification of words. Furthermore, the results were the same in a second experiment that required the story context to be read rather than heard. Despite their inefficiency in word coding and their relatively low level of comprehension, less-skilled readers could get contextual information out of a printed text sufficient to guide word identification.

A further result of these two experiments is informative. For a skilled reader, identification time for a word in context was uncorrelated with the word's identification time in isolation. For less-skilled readers, a word's identification time in context was correlated with its identification time in isolation. Thus, less-skilled readers showed some evidence that intrinsic codability factors, e.g., word length and frequency, continued to be a factor in context. However, for both groups of readers the word's predictability in text was a major determinant of identification latency.

In a third experiment using the same story texts, Perfetti et al (1979) had subjects predict the word they were about to see.

Immediately after their prediction, the target word was exposed. This allowed an interesting comparison. How would the identification time of a word that was accurately predicted compare with one that was not accurately predicted? In fact, identification times were shorter for a correctly predicted word. However, there was evidence to suggest that when a target was not predicted successfully, skilled readers had less trouble with it than less-skilled readers. When both the target word and the word predicted by the subject were contextually appropriate, there were an extra 50 milliseconds required by the skilled reader to identify the actually occurring target. The increase for the less-skilled reader was about 180 milliseconds. The comparison is somewhat questionable because words not predicted were not the same for any two readers and skilled readers made more correct predictions. However, the suggestion of the comparison was that skilled readers did not much need an exact target prediction for fast identification. Less-skilled readers seemed, by contrast, to be rather dependent on accurate prediction.

Surprising Contexts

This suggestion was given further test by use of what can be called "bottom-up" surprises. These are cases in which conceptual guidance provides data that are not useful. What actually appears as a word is a surprise. For example, if text (1) were completed, not by ticket but by carrot, the text completion is somewhat anomalous. Note if the completion word were ticker the context would not only be anomalous but the graphic data would provide significant convergence

with the conceptual data (tick). A misreading of ticket for ticker is a reasonable possibility in such a case, because the effect of context may be to lower a decision criterion concerning how much graphic data to accumulate before making a word decision. The completion of carrot is a quite different matter. It brings graphic data into complete conflict with conceptual data. It's the carrot case we've studied: What happens when a young reader encounters a word not fitting the context?

According to the model of reading skill which emphasizes verbal coding efficiency (Perfetti & Lesgold, 1977; 1979) the effect of such a surprise should be a function of a reader's basic rate of (bottom-up) word processing, i.e., a rate of word identification out of context. A reader with a normally fast base rate for word identification will identify words quickly with or without context. Context effects may be slower to execute than the reader's basic rate. If so, such a reader will not be dependent on context, and given a misleading context the basic identification process will be completed before the slower acting context process. By contrast, the reader with a slow basic rate of (bottom-up) word identification will be adversely affected by a misleading context. This is because the contextual process, the conceptual guidance, has led to some (perhaps) specific expectancies about what word might be about to occur. When a different word actually occurs, e.g., carrot instead of ticket, the processes which use graphic data to find a memory entry have to be initiated anew and carried out completely. Guessing or accepting incomplete analysis will not be enough. Identification should be

slow.

This hypothesis, developed further in Perfetti and Roth (in press), was tested by constructing short texts not unlike the original ticket example (1). The texts were completed by targets that were predictable, unpredictable, or anomalous. Predictable completions were words that were highly predictable, in fact, predicted 80% by a sample of subjects. Ticket in text (1) would be an example. Unpredictable completion were words which were semantically acceptable but not likely to be predicted: Money would be such a word as a completion of Text (1). The anomalous texts were semantically unusual as well as unpredictable. Carrot in Text (1) would be an example of an anomalous context.

The identification time data confirmed the expectancies concerning these contexts. When a word occurred in an unpredictable context its average identification time was 706 milliseconds for a skilled reader and 863 milliseconds for a less-skilled reader (4th grade subjects). When the context was 80% predictable, the identification times were reduced by 96 milliseconds for skilled readers and by 170 milliseconds for less-skilled readers. Again, we see not only a beneficial effect of context for the less-skilled reader, but an effect greater than for the skilled reader. With this highly predictable context, the mean difference between skilled and less-skilled readers in identification times was reduced to 81 milliseconds.1

The anomalous contexts produced especially interesting results. Compared with identification times in unpredictable contexts,

less-skilled readers' mean identification times increased by 104 milliseconds (to 962 milliseconds). Skilled readers' times increased by only 9 milliseconds (to 717). Thus, skilled readers were not affected by anomalous contexts but less-skilled readers were. It is perhaps interesting that with subjects one year younger, both skilled and less-skilled readers were negatively affected by anomalous contexts. There may be a developmental progression from heavy reliance on context to reduced reliance on context or at least to a willingness by the child to trust his or her bottom-up processes.

The research summarized here points to an important, even if tentative, conclusion concerning reading skill. Children who are not good readers have no trouble using context to identify words. Indeed, they give evidence of being very affected by context. Their identification of words is greatly speeded up when a word is predictable and greatly slowed down when a word is unexpected. This conclusion has support not only from the research reported in Perfetti et al (1979), and Perfetti and Roth (in press), but also in the research of Stanovich (in press; Stanovich & West, 1979).

Contextual Abilities

It would be an error to conclude that the present account entails that less-skilled readers have context abilities equal to skilled readers. The supportable conclusion is that they have context abilities sufficient to dramatically affect their identification latencies. There is no less reason to assume that individual talents vary in contextual abilities than to assume they vary in verbal coding

abilities.

Indeed these talents are correlated. In one of the studies of Perfetti et al (1979) data were available both on subjects' word identification times to isolated words and their accuracy at predicting the next word in a story. The correlation between these two measures was -.60. That is, shorter basic word identification times were associated with higher accuracy in predicting the next word in a story. When prediction performance was compared for the skilled and less-skilled readers, the percent correct predictions were 33 and 22, respectively. Clearly, skilled readers are skilled both at bottom-up and top-down aspects of reading.

A recent study reported in Perfetti and Roth (in press) explored the nature of context ability and differences between skilled and less-skilled readers in this ability. Children (fourth grade) heard short two-sentence texts and then were given 15 seconds to produce as many words as possible that could complete the text. The texts were constructed so as to represent three levels of textual constraint. With high constraint, the target word is nearly inevitable, as in text (2).

(2) On the way to school, Harry met a friendly dog. The dog ran up to him and began to wag his _____.

In such a constraining context, a child quickly exhausts the list of possible completions--tail, tongue, ears. Less-skilled readers as well as skilled readers produce the most probable target, tail. Overall high constraint contexts produced few different response types

and high accuracy for the particular target, 93% and 94% for skilled and less-skilled readers, respectively.

By contrast, low constraint, exemplified by (3) below, is a text for which a large set of completions is possible.

(3) Sam was driving his son to the dentist. On the way, his son wanted to stop to look at the _____.

The number of possible completions in this text is very large. Both skilled and less-skilled readers produced a large number of different completions and seldom produced the completion that the experimenters had in mind (and would later produce in a reading task). The prediction accuracy was less than 1% for each group.

Intermediate between these two text types are the moderately constraining texts represented by (4).

(4) When I got home from work, I wanted to eat a fruit. I went to the refrigerator and got a _____.

The possible set of completions is larger than for text (2) and smaller than for text (3). For moderate constraint texts, the number of different words produced in 15 seconds was less than the number of different responses to the Low Constraint texts. Skilled and less-skilled subjects did not differ much in the number of different words produced. However they did differ in their prediction of the actual target (pear in this case), with skilled readers predicting about 24% of the words compared with 15% for less-skilled readers.

It's largely a matter of conjecture to begin to explain the

difference in context performance that emerges in these texts of moderate constraint. However examining individual texts produced some interesting possibilities. Less-skilled readers tended to produce completions that did not honor all the constraints of the text. Note that in text (4) there are two constrants imposed by the text. The completion must be the name of a fruit and it must be the name of an object that could be in a refrigerator. Some less-skilled readers produced responses that seemed to honor only the refrigerator constraint. For example, words such as cake, pie, pizza were produced. Such subjects either forgot the fruit constraint or quickly exhausted their fruit list and were forced to ignore the constraint.

One hypothesis to consider is that multiple constraints cause problems across sentence boundaries. In (4) the fruit constraint was imposed by the first sentence and the refrigerator constraint was imposed by the second sentence. A requirement of comprehension is that relevant information from prior text be kept active in memory. It is possible that some memory deactivation of prior text is occurring for some children even during listening. (The contexts were spoken.) There are other possible sources for individual differences in context ability (see Perfetti & Roth, in press) and there is little basis in evidence yet for favoring one over the other.

For now, the conclusion is that individuals differ in their use of context to predict words when moderately constraining contexts are considered. Less-skilled readers have no problem with high constraint texts and they have contextual abilities sufficient to guide word identification. They are, however, doubly handicapped in being

patently slower at basic word coding and subtly less effective in constructing high quality semantic representations of text.

Degraded Graphic Data

Just as the importance of word level processes can be seen when the quality of conceptual data is degraded, the importance of conceptual data can be seen when the quality of graphic data is degraded. Results of studies which have simultaneously varied the quality of context and the quality of graphic data are available and reported in more detail in Perfetti and Roth (in press).

Degrading of graphic data was accomplished by the deletion of computer printed letter segments. Examples of degraded words are shown in Figure 1. The words shown in Figure 1 are degraded by 0%, 21%, 42%. In one of the experiments using this procedure, words were degraded at 14% and 35%.

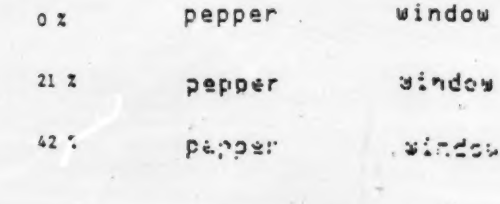

Figure 1
Three levels of Degrading

In two experiments, words that varied in their degree of visual degrading were presented for identification in contexts of different sorts. In one experiment the context was the stories used by Perfetti et al (1979). In another, the contexts were the short two sentence texts constructed to represent high, moderate, and low constraint, as discussed in the previous section. The two experiments produced very similar results concerning the issues being addressed here (see Perfetti & Roth, in press for details).

One general result, of course, is that errors are made on degraded words. Even at 14% degrading, errors are made by both skilled and less-skilled readers. However, when the words are in a story context, identification of a word remains nearly perfect up to between 21% and 28% degrading. Since the average predictability of words in the story was 26%, the result can be described as a trade off: A text that was 26% predictable compensated completely for a graphic data reduction of 21%. A similar conclusion comes from considering identification times instead of accuracy.

A second important result is that these experiments found greater context effects for less-skilled readers, in agreement with studies summarized before. Both the accuracy and identification times of less-skilled readers were facilitated more by context.

A third result is that less-skilled readers were more affected by word degrading than were skilled readers. For example, in one of the experiments, at zero degrading skilled readers were about 170 milliseconds faster than less-skilled readers. At 21% degrading their advantage had increased to nearly 300 milliseconds and by 42%

degrading it was nearly half a second.

This is the kind of result one would expect given a model of reading skill that emphasizes the role of word-level processes. The skilled reader may have knowledge concerning graphic patterns that is useful when the graphic data are impoverished. There was no evidence that this was a matter of superior ability to use context to figure out the word. The advantage of the skilled reader was just as great for isolated degraded words.

One further observation concerning these data is that the degrading procedure allows a skilled reader to look like a less-skilled reader. For example at 21% degrading skilled readers had the same identification times as less-skilled readers at zero degrading. Moreover, at 21% degrading the effect of context on a skilled reader became equal to the effect of context on a less-skilled reader at zero degrading. Recall that in the ordinary case, context affects less-skilled readers more. What this illustrates is that if a skilled reader's word identification is slowed down, then it is affected by context to the same degree as the less-skilled reader. This reinforces the view that skilled word identification normally occurs so rapidly that there is little chance for context to be a significant factor.

Conclusion

It is important to understand reading as an interactive process. This paper has discussed interactive processing by focusing on two general sources of information in word identification. Things of

course are considerably more interesting than this. For example, the low-level sources of information that are useful are probably varied across visual pattern information, orthographic constraints and phonemic codes. Further, there are other process interactions at higher levels to be considered.

However, within the scope of this discussion, the major conclusions concern word identification. It occurs in normal reading as a result of information from multiple sources. One can observe the value of one information source by disrupting some other source. Reading failure can, and perhaps does, occur as a result of problems of ineffective conceptual guidance. However, there seems to be evidence that conceptual guidance is not something that has been denied to the child who doesn't read well. This conclusion at least applies to children of normal IQ in regular classrooms in the middle grades. While such children seem to have some subtle problems in contextual processes, they can use context very well in word identification. Indeed, they show signs of being dependent on context in compensation for inefficient word coding abilities.

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Footnotes

1. It is legitimate to wonder whether the smaller reduction for the skilled readers is a matter of measurement insensitivity, i.e., whether the possibilities for reduced times were not as great for skilled readers because of their already fast times. There are a couple of reasons for not preferring this interpretation. One is that it will not explain the skilled readers' small increase in latency when context is anomalous. The model that assumes the context identification gains or losses are a function of both context use and basic word processing rate explains both findings (see Perfetti and Roth, in press).